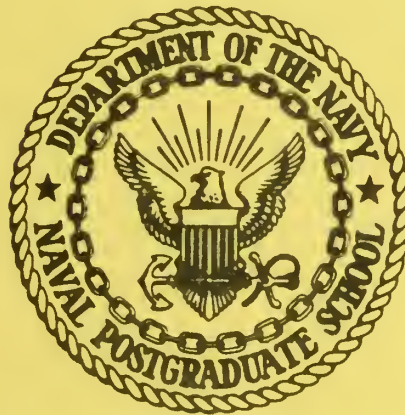


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NAVAL POSTGRADUATE SCHOOL

Monterey, California



THE NAVY'S EDUCATIONAL PROGRAMS
IN ELECTRONIC WARFARE

David B. Hoisington
CDR C. J. Thomas, USN

May 1977

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THE NAVY'S EDUCATIONAL PROGRAMS IN ELECTRONIC WARFARE

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ABSTRACT

The Navy's educational programs in electronic warfare are conducted at the Naval Postgraduate School in Monterey, California. Curricula leading to the Master's Degree are available in Electronic Warfare Engineering and in Electronic Warfare Systems Technology. Successful Naval officer graduates of both curricula receive a P-code. Both programs are available to officer of the other services as well as to DoD civilians.

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THE NAVAL POSTGRADUATE SCHOOL

The Naval Postgraduate School has been providing advanced education for Naval officers for nearly seventy years. Established in 1909, the School operated on the Naval Academy grounds until the early 1950's, when it moved to Monterey, California. Doctoral and Engineer degrees are now awarded in several technical disciplines and the Master's degree is awarded in all disciplines for which there are programs. Growth and the changes which accompanied it have been brought about because as ship and aircraft systems became increasingly complex, education at the Naval Postgraduate School had to also change and expand to keep pace with the rapidly emerging technology which has governed the development of these new systems. If our professional military men are to operate, manage, and command these complex combat systems effectively, it is essential that the Navy maintain a wide range and depth of basic scientific and technical knowledge within its officer corps. The mission of the Naval Postgraduate School provides for this advanced education.

THE NEED FOR POSTGRADUATE ELECTRONIC WARFARE EDUCATION

As the Navy sought to develop a capability in electronic warfare, new equipment introduced into the fleet was supported by a nucleus of officers and men trained in its operation. Optimal equipment employment and tactics were developed by the operational forces, and personnel were trained both on the job and at special schools. A prime example of a training activity established to support Naval electronic warfare is the Naval Technical Training Center, Corry Station, Pensacola, Florida [1].

Although training programs such as those described above provide for the development of expertise in certain areas, it was recognized that something more was required. This requirement was the need for a cadre of officers representing all electronic warfare platforms; officers who understood the underlying principles of the elements of EW, elements such as the environment, the potential enemy's capabilities, system capabilities, principles of coordinated Electronic Warfare, and so on. While training programs are essential to ensure optimum system operations, such programs have not necessarily provided an understanding of the broad principles required to optimize total systems capabilities. To provide an education of this type is the function of the postgraduate educational program.

THE BILLET CODING SYSTEM

Advanced education in the Navy is integrally related to certain specified jobs or billets: all positions requiring an advanced education are coded, listed, and updated frequently. A billet requiring an engineering electronics graduate with specialization in electronic warfare, for example, is XX57P. The "XX57" signifies the specialization area and the "P" signifies that advanced education is required. The last letter might alternatively be a "Q" (meaning requiring an officer who holds a "P" code but whose high performance in EW has been noted by a screening board, and thus is considered a qualified performer) or an "H" (signifying a billet not requiring a P-coded officer, but a billet in which one could be effectively utilized).

The total number of identified P and Q coded billets drives a model which determines the size of the officer community needed to fill those billets on a continuing basis, and determines the number of officers who should enter graduate programs each year. H coded billets are not included in the model and hence do not affect the size of the specially educated officer community.

THE ELECTRONIC WARFARE GRADUATE PROGRAMS

The Naval Postgraduate School currently offers two advanced curricula in electronic warfare: Electronic Warfare Engineering and Electronic Warfare Systems Technology. Electronic Warfare Engineering, Curriculum 591, until recently an option of the Engineering Electronics curriculum, has now been identified as a separate curriculum for quota control purposes. The objective of the curriculum remains to provide an officer with a comprehensive scientific and technical knowledge in the field of electronics engineering as applied to Defense and Navy systems, with special emphasis directed towards electronic warfare systems. The prerequisites for the curriculum include a baccalaureate degree with a background and above average grades in differential and integral calculus and in elementary college physics. The program is open to officers of grades lieutenant (junior grade) through lieutenant commander, as well as to Marine Corps, Army, and Air Force officers of equivalent rank, and to Department of Defense civilians. Officers of Allied Nations can also be accommodated.

The School's new EW program is called Electronic Warfare Systems Technology. The objective of this curriculum is to provide the services with officers thoroughly knowledgeable in the technical and operational aspects of both the art and

role of electronic warfare as a vital, integral part of Naval warfare. The prerequisites include a baccalaureate degree or equivalent with mathematics through calculus and preferably a previous tour of duty providing a background of operational experience. The applicant must be eligible to obtain a Top Secret security clearance with special intelligence access. This program is available to U. S. military officers of the rank of lieutenant (junior grade) through lieutenant commander or equivalent rank, and to Department of Defense civilians. It is not available to officers of Allied Nations.

The tuition for Department of Defense civilians of \$500 per quarter in any program is paid by the student's sponsoring organization. Candidates for the two EW programs described above who are lacking in the requisite mathematics and/or technical fundamentals may be accepted into either program by way of the two-quarter engineering science preparatory program at the Naval Postgraduate School or through participation in courses offered through extension.

DURATION OF COURSES OF STUDY

All graduate programs at the Naval Postgraduate School include a graduate preparatory phase in addition to the graduate program. The preparatory phase is included since the average Naval officer entering the school has been away from school for about seven years and requires a considerable amount of review of basic mathematics and physics, and updating on recent advances in the state-of-the-art. Many officers enter graduate programs in subject areas different from their undergraduate discipline. Consequently, the typical master's program for an entering officer is four quarters of graduate work preceded by four quarters of preparatory studies, or two full years (the school operates the year around).

Not all officer and civilian students are required to remain at Monterey for two years to complete these programs. The time in residence may be reduced by validating courses where the student is able to demonstrate proficiency in the subject matter. A course can be validated if a student has completed an equivalent course elsewhere with a satisfactory grade and has retained sufficient skill in the subject to proceed with other courses for which the course in question is a prerequisite. In a few cases, an undergraduate course can be validated based on an officer's job experience in related areas.

Every effort is made to provide means for validating courses to minimize the required time on board. Officers are encouraged to take required courses at colleges in the vicinity of their shore duty stations before entering the Naval Postgraduate School. Many of the undergraduate courses are

available from the Naval Postgraduate School in personalized system of instruction (PSI) format. These courses may be taken on shore or at sea; most, but not all, require that a qualified tutor be available to assist the student. The Naval Postgraduate School provides assistance in finding tutors such as officers who have previously completed a similar course with good grades. The number of courses available in PSI format is continuously increasing.

Department of Defense civilian students generally require considerably less time on board than do Naval officers. The civilian student usually has a baccalaureate degree in his area of study. Moreover, he typically has been working continuously in the discipline and has retained his mathematical skills because of continuous use. The typical civilian time on board is four or five quarters, although this can be reduced still further if a student completes his thesis at his place of employment.

ELECTRONIC WARFARE ENGINEERING

The Electronic Warfare Engineering program, curriculum 591, is a four-quarter graduate program with a maximum of five preparatory quarters leading to the degree of Master of Science in Electrical Engineering. Most officers enter this curriculum in October or March, but entry in January or July is also possible. Successful completion leads to the XX57P code for Naval officers. It is the program taken by those Naval officers who expect to become Engineering Duty Officer (EDO) as well as by many line officer electronic warfare specialists. Graduates are prepared for shore billets requiring engineering skills such as project managers.

Table I lists typical undergraduate and graduate courses for the program. A provision for electives permits a degree of flexibility to accommodate the special interests of individual students. The course, Communications in Organizations, covers management strategies to effectively employ human resources in accomplishing unit missions. It is required of all Naval officers but an elective may be substituted by other students.

A thesis is required of all students in the program. Four course slots are provided for the thesis, the equivalent of a full quarter, although actual work is generally spread over three quarters. For Naval officers, the thesis often provides the only opportunity the officer has during his career to carry a piece of engineering work through from start to finish on his own. It is an invaluable experience for later dealings with Naval contractors.

TABLE I. TYPICAL COURSES IN CURRICULUM 591,
ELECTRONIC WARFARE ENGINEERING

MATHEMATICS

- | | |
|-------------------------------|-------------------------|
| *Calculus and Vector Analysis | *Differential Equations |
| *Computational Matrix Algebra | *Complex Variables |

PHYSICS

- | | |
|--|-----------------|
| *Review of Mechanics,
Electricity and Magnetism | *Wave Phenomena |
|--|-----------------|

CIRCUITS AND CONTROL

- | | |
|-----------------------|--------------------------|
| *Basic Circuit Theory | *Linear Systems Analysis |
| *Circuit Analysis | *Control Systems |

ELECTRONICS AND COMMUNICATIONS

- | | |
|---|--|
| *Electronics Engineering
Fundamentals I and II | *Communications Circuits
Stochastic Analysis of Signals |
| *Pulse and Digital Circuits | Microwave Devices |
| *Communication Theory | Statistical Communication Theory |

COMPUTER SCIENCE

- | | |
|---|-------------------|
| *Introduction to Computer Pro-
gramming with FORTRAN | *Digital Machines |
|---|-------------------|

ELECTROMAGNETICS

- | | |
|--------------------------------------|--|
| *Introduction to Fields and
Waves | *Electromagnetic Engineering
Electromagnetic Radiation and
Compatability |
|--------------------------------------|--|

ELECTRO-OPTICS

- | | |
|---|-------------------------------------|
| Engineering Fundamentals of
Electro-Optics | Electro-Optic System
Engineering |
|---|-------------------------------------|

ELECTRONIC SYSTEMS

- | | |
|--|---|
| Advanced Radar Systems | Signals Intelligence (SIGINT) |
| Electronic Warfare Techniques
and Systems | Systems Engineering
Missile Guidance Systems |

MANAGEMENT

- | | |
|---|-----------------------------|
| Communications in Organizations
Project Management | Defense Resource Allocation |
|---|-----------------------------|

*Preparatory courses

TABLE II

RECENT UNCLASSIFIED ELECTRONIC WARFARE THESES

- V. J. McCarthy, LT, USN, C. J. Thomas, LCDR, USN, and J. E. Kirzl, LCDR, USN, "System Definition of the Sensor, Data Link, and Surface Terminal Requirements for the Tactical Airborne Signal Exploitation System (TASES)", MS, March 1974.
- G. W. Mitschang, LT, USN, "Effects of Atmospheric Turbulence on Laser Communications", MSEE, June 1974.
- P. D. Frazer, LCDR, USN, "The Electronic Warfare Application of Special Purpose Microprogrammed Minicomputers", MSEE, June 1974.
- E. L. Bell, LTJG, USN, "An Algorithm for Rapid Classification and Recognition of Modulation Types in the HF Band", MSEE, September 1975.
- B. F. Schwoerer, LT, USN, "Probability of Intercept in Electronic Countermeasures Receivers", MSEE, December 1975.
- W. Y. Frentzel, II, LT, USN, "A Digital Computer Analysis of the Wullenweber Antenna: High Band Narrow Sector Pattern", MSEE, December 1976.
- P. P. Aranciba, LT, Chilean Navy, "Implementation of a Side-lobe Blanking System on the AN/SPS-12 Radar", AE, March 1977.
- R. H. Shumaker, CAPT, USN, "Maximization of Missile Miss Distances by a Maneuvering and Jamming Airborne Target", PhD, June 1977.
- K. D. Watts, CAPT, USMC, "Electronic Warfare Support Jamming Route Optimization", MSEE, June 1977.
- C. A. Beaudet, LT, USN, "EA-6B Mission Planning Program, MSEE, June 1977.

An officer is encouraged to select a thesis topic which is relevant to the needs of the Navy and to his expected career pattern. Suggestions for relevant topics are solicited from Navy laboratories, Systems Commands, operational units, and contractors on a continuing basis. Faculty members engage in related sponsored and unsponsored research. This research is the source of many relevant thesis topics. Table II lists some recent EW thesis topics.

ELECTRONIC WARFARE SYSTEMS TECHNOLOGY

The multidisciplinary Electronic Warfare Systems Technology (EWST) program, curriculum 595, had its first input of eleven students in March 1977, and inputs will occur annually in March of future years. It is a four-quarter graduate program (plus a maximum of four preparatory quarters) leading to the degree Master of Science in Systems Technology. Successful completion leads to the XX46P code for Naval officers. Table III is a summary of H, P, and Q coded billets that will be staffed by Naval officer graduates of the program.

Table III shows that the program supplies officers primarily for operational billets, staffs, the intelligence community, test and evaluation, and for training billets. Table IV lists the courses included in the program. Graduates are not intended to be design engineers, but the curriculum includes enough engineering at the systems level (there is little circuit design) so that graduates can understand the operation, capabilities, and limitations of electronic warfare systems. The graduate should be able to translate fleet electronic warfare requirements into realistic specifications for new systems and to appraise objectively the operational and engineering capabilities and limitations in existing systems.

Program courses in meteorology, underwater sound systems and countermeasures, computer science, electromagnetics, antennas, propagation, radar, electro-optics, and electronic warfare are a vital part of the program. Equally important are the courses in intelligence and operational and systems analysis. The five courses in the OR/SA sequence are designed to make the officer a sophisticated user of quantitative measures for the purpose of making decisions concerning electronic warfare tactics and equipment.

Four thesis slots (one quarter equivalent) are provided in the EWST curriculum. It is expected that many theses will be multi-disciplinary, utilizing the students' knowledge in computer science, systems analysis, and intelligence, as well as in electrical engineering.

TABLE III. H, P, AND Q-CODED BILLETS
ELECTRONIC WARFARE SYSTEMS TECHNOLOGY SUBSPECIALTY (XX46)

89 P or Q-Coded billets, 90 H-coded billets, as follows:

H-Coded

Shipboard	48
A/C Squadron	31
Other	11
Total	90

P or Q-Coded

Office of SECDEF	2
Joint Staff	3
OPNAV	7
Analysis & Intelligence	1
Research & Development	7
Test & Evaluation	6
Training	8
Operational (Ship or A/C Sqdn). .	7
Operational (Staff or Support). .	48
Total	89

Grand Total: H + P/Q Billets 179

TABLE IV. COURSES IN CURRICULUM 595
ELECTRONIC WARFARE SYSTEMS TECHNOLOGY

MATHEMATICS

*Calculus Review	Fourier Analysis, Partial Dif-
*Differential Equations, La Place Transforms	ferential Equations
*Vector Calculus	Applied Probability Theory

COMPUTER SCIENCE

*Introduction to Computing Real-Time Systems and Structures	Electronic Warfare Computer Applications
--	---

INTELLIGENCE

*Naval Warfare and National Security	Signal Intelligence and the Threat Environment
---	---

PHYSICS AND ELECTRO-OPTICS

*Basic Physics	Electro-Optic Principles & Devices
*Fundamentals of Electro-Optics	Electro-Optic Systems and Countermeasures

ELECTRICAL ENGINEERING

*Introduction to Electronic Systems	Introduction to Signals and Noise
*Pulse and Digital Circuits	Signal Processing Systems
*Control Systems	Microwave Devices and Radar
*Electromagnetic Theory	Electronic Warfare Systems
Electromagnetic Radiation, Scattering & Propagation	

OPERATIONS RESEARCH

Decision Analysis and Data Analyses	Operations Analysis for Elec- tronic Warfare
Simulation and War Gaming	Operational Test and Evaluation
Human Factors	

MISCELLANEOUS

*Meteorology for Electronic Warfare Underwater Sound, Systems, and Countermeasures	Communications in Organizations
--	---------------------------------

*Preparatory Courses

In order to fit all the required subjects into this program, there was little room left for electives. The Naval officers who is unable to validate any courses has no room for an elective. Other officers and civilians may take an elective in place of Communications in Organizations. A large fraction of students can validate one or more courses so that electives can be fitted into their programs.

Design of the curriculum was based on the School's experience with the highly successful Antisubmarine Warfare Systems Technology (ASWST) curriculum which has been in operation since 1974. Eleven of the courses in the curriculum were originally designed for ASWST. To the maximum feasible extent, courses already in the Naval Postgraduate School catalog were used in order to keep down the cost of the program. Because of its unique nature, 55% of the coverage is new, consisting of courses specifically designed for the curriculum.

REFERENCE

- 1 . LCDR H. J. Scarborough, "The Navy's New EW School: Off to a Good Start on the Florida Coast", Electronic Warfare, Vol 8, No. 5, pp 85-89, Sep/Oct 1976.

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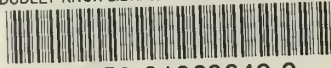
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